A COMPREHENSIVE, DISCRIMINATING, SYNERGISTIC, AND REALISTIC SUITE OF INSTRUMENTS FOR IN SITU ANALYSIS OF MARTIAN SURFACE MATERIALS: A DEMONSTRATION USING MARTIAN ANALOGUE SAMPLES AND PROTOTYPE FLIGHT INSTRUMENTS. R. V. Morris (NASA Johnson Space Center, Houston, TX 77058 morris@snmail.jsc.nasa.gov), J. F. Bell III and S. W. Squyres (Cornell University), P. H. Christensen (Arizona State University), T. Economou (University of Chicago), G. Klingelhoefer and P. Held (T.H. Darmstadt), B. L. Jolliff, A. Wang, and L. A. Haskin (Washington University).

Introduction. The scientific study of Mars by surface landers necessarily requires instrumentation for elemental and mineralogical analyses of surface materials. An example of a scientifically and technically viable instrument payload would include a panoramic camera with multispectral imaging capability (Pancam), a thermal emission spectrometer (TES), an alpha proton X-ray spectrometer (APXS), a Mössbauer spectrometer, and a Raman spectrometer (collectively referred to as an Athena payload). In order to demonstrate the comprehensive, discriminating, and synergistic nature of an Athena payload, we analyzed seven Martian analogue samples using flight prototypes for TES APXS, and Mössbauer instruments, a laboratory Raman instrument, and Pancam spectra calculated from convolution of laboratory reflectance data over Pancam bandpasses.

Samples. We analyzed Zagami (a SNC meteorite) that contains primary igneous phases and six analogues for Martian surface materials. TRATIV1 is a sample of massive calcite (travertine). The remaining four samples are heavily oxidized. HWMK600 and HWMK24 are palagonitic and jarositic tephra samples from Mauna Kea (HI). BCS-301 is a chemical standard derived from an iron ore deposit. AKB-1 is an amygdaloidal basalt from the Keweenawan peninsula (MI). MAN-74-342A is an impact melt rock from Manicouagan Crater (CAN).

Results and Discussion. Representative spectra from an Athena payload are shown in Figure 1. Specific elements and mineralogies firmly identified in each sample are listed in Table 1 by instrument. Note (1) that the APXS instrument has good energy resolution which produces high-quality elemental abundance data and (2) that the mineralogy instruments (particularly Mössbauer and Raman) provide a detailed and comprehensive mineralogical assessment. Although Mössbauer and Raman are the most sensitive to mineralogy, they (like APXS for elemental abundance measurements) require proximity to samples for analysis. Because Pancam and TES can do analysis on any area in the field of view, they can be used to map rock types whose precise mineralogies (and elemental composition) are determined with all five instruments. The figure and table are a striking demonstration of how the instruments will work together in different and complementary ways to analyze Martian materials than would be provided by any single measurement technique alone.

Table 1. Elements (>2% abundance) and mineralogies firmly identified by Athena instruments.

Sample	Elements- APXS X-Ray + Alpha	Minerals Pancam	TES	Mössbauer	Raman	Minerals Ident. in Sample (1)
TRATIV1, Calcite	C, O, Ca	None	Cal	(2)	Cal	Cal
Zagami, SNC Meteorite	C, O, Na, Mg, Al Si, Ca, Fe	Px	Px	Px, Ol, Ilm	(2)	Px, Ol, Ilm
HWMK600, Palag. Tephra	C, O, Na, Mg, Al Si, K, Ca, Ti, Fe	npOx	None	Ol, npOx TiMt	Px, Ol Plag	Ol, Plag, npOx TiMt
HWMK24, Jarositic Tephra	C, O, Na, Mg, Al Si, S, K, Ca, Ti, Fe	Fe(3+)-Mineral	None	Jar	Jar	Jar
BCS-301, British Chemical Std.	C, O, Na, Mg, Al Si, Ca, Mn, Fe	Gt	Carb-onate	Gt, FeCal	FeCal	Gt, FeCal
AKB-1, Amygd. Basalt	C, O, Na, Mg, Al Si, Ca, Fe	Hm	Silicate Fe-Oxide	Hm, npOx	Cal, Zeo Phy	Hm, npOx, Zeo Cal, Phy
MAN-74-342A, Impact Melt Rock	(2)	Hm	None	Hm, Phy npOx	(2)	Hm, npOx, Phy
Summary of minerals identified for each instrument and for all instruments.		Px, Hm Gt npOx	Px, Cal	Px, Ol, Hm Ilm, TiMt Gt, npOx Jar, FeCal	Px, Ol Plag, Phy Zeo, Cal FeCal, Jar	Px, Ol, Plag, Phy Zeo, Hm, Gt TiMt, Ilm, npOx Jar, Cal, FeCal

1. Ol = olivine; Px = pyroxene; Plag = plagioclase feldspar; Zeo = zeolite; Phy = phyllosilicate; TiMt = titanomagnetite; Ilm = ilmenite; Hm = hematite; Gt = goethite; npOx = nanophase ferric oxide; Jar = jarosite (an Fe(3+) sulfate); Cal = calcite; FeCal = Fe-bearing carbonate. 2. Not analyzed.

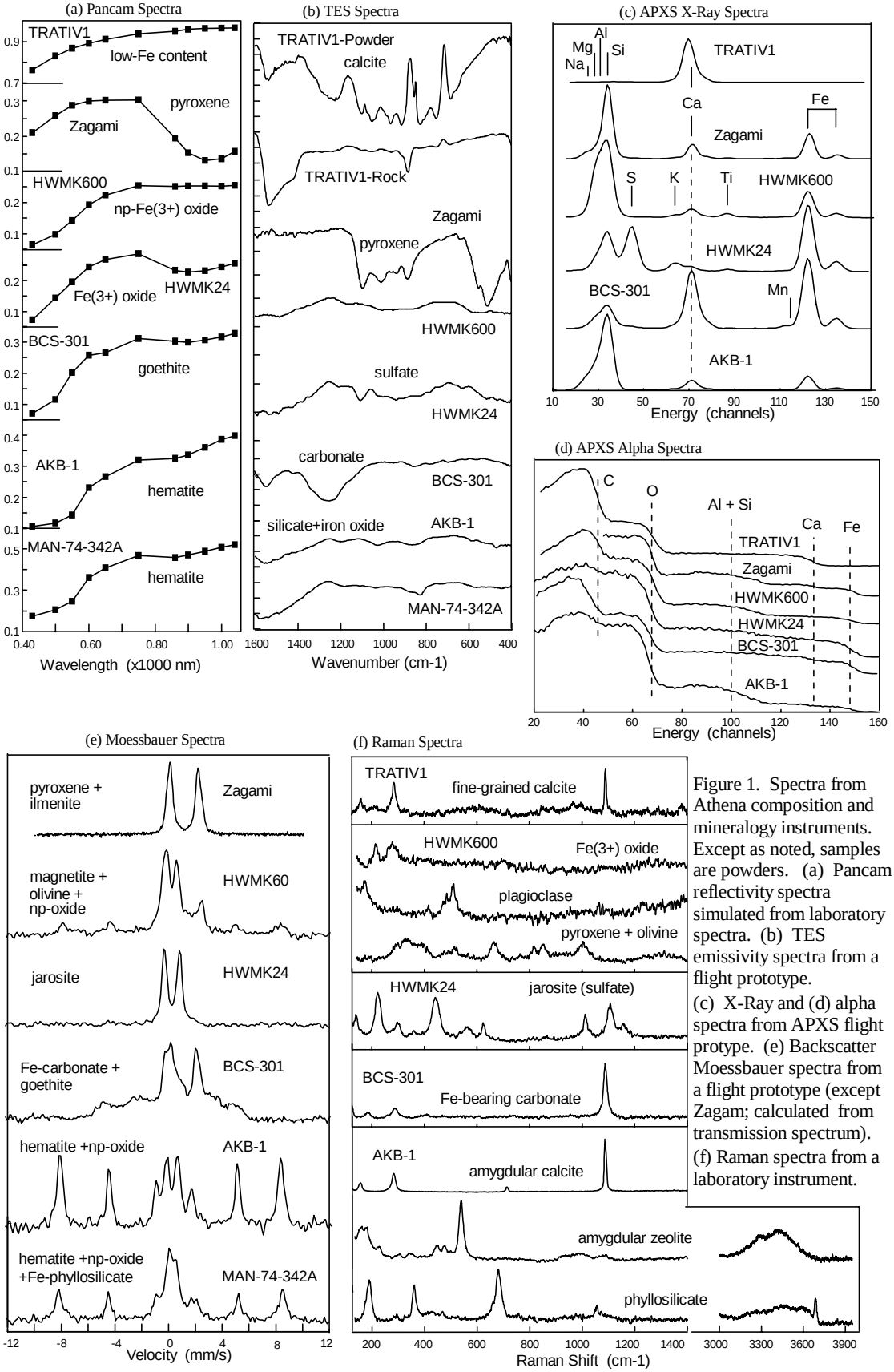

Figure 1. Spectra from Athena composition and mineralogy instruments. Except as noted, samples are powders. (a) Pancam reflectivity spectra simulated from laboratory spectra. (b) TES emissivity spectra from a flight prototype. (c) X-Ray and (d) alpha spectra from APXS flight protype. (e) Backscatter Moessbauer spectra from a flight prototype (except Zagam; calculated from transmission spectrum). (f) Raman spectra from a laboratory instrument.